Multi-sensor Improved Sea-Surface Temperature (MISST) for IOOS – Navy component

Charlie N. Barron
NRL Code 7321
Stennis Space Center, MS 39529
phone: (228) 688-5423 fax: (228) 688-4759 email: charlie.barron@nrlssc.navy.mil

Award Number: N000141221311
https://www.ghrsst.org/

LONG-TERM GOALS

Ensure that Navy capabilities for a new generation of sea surface temperature products are coordinated with and benefitting from international research and development embodied by the Group for High Resolution Sea Surface Temperature (SST; GHRSST) and domestic capabilities demonstrated in the U.S. Integrated Ocean Observing System (IOOS) regions and applicable to regions around the world. This project is the Navy component of a broad national NOPP/IOOS/NASA MISST for IOOS project led by Chelle Gentemann. The Navy Participants under the ONR funding are Charlie Barron (NRL), James Cumming (NRL), Bruce McKenzie (NAVOCEANO), and Doug May (NAVOCEANO).

OBJECTIVES

The overarching objectives in MISST for IOOS are to continue producing GHRSST compliant satellite SSTs from existing and new sensors and to produce multi-sensor blended gap-free SSTs from US and international GHRSST datasets. The objectives of the Navy component are to coordinate Navy research and development with GHRSST through complementary tasks and interaction at the annual meetings, use of GHRSST data sets for assimilation and validation, and intercomparison of Navy and other GHRSST products. The Navy participants have work elements that support the five MISST for IOOS project tasks:

1. Computation of sensor-specific observational error characteristics required for optimal application and data fusion techniques.
2. Parameterization of IR and MW retrieval differences, with consideration of diurnal warming and cool-skin effects required for multi-sensor blending.
3. Retrospective reanalysis, continued NRT production, and dissemination of sensor-specific SST products with associated retrieval confidence, standard deviation (STD), and diurnal warming estimates to the application user community in the new GDS 2.0 GHRSST format.
4. Retrospective reanalysis, continued NRT production, and dissemination of improved multi-sensor high-resolution SST analyses in the new GDS 2.0 format, to demonstrate and optimize utility in IOOS and operational applications.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2012	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Multi-sensor Improved Sea-Surface Temperature (MISST) for IOOS Navy component	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **NRL Code 7321 Stennis Space Center, MS 39529**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**4**	

5. Targeted applications of the SST analyses for the benefit of IOOS, including coral reefs, ocean modeling in the Gulf of Mexico, improved lake temperatures, numerical data assimilation by ocean models, numerical weather prediction, and operational ocean forecast models.

The Navy goal is to make more effective use of data streams and techniques developed by the collective MISST/GHRSST efforts. As a part of this cordination, the Navy component of MISST for IOOS evaluates regional application of Navy products that emphasizes performance in US coastal regions. This project will also work to leverage results of potential Navy interest from other MISST IOOS performers.

APPROACH

Under the Navy component of MISST for IOOS, specific tasks have been identified to leverage and extend existing work in a way that furthers development of operational Navy capabilites and supports the broader MISST for IOOS objectives. In addition to participating in the GHRSST meetings with the MISST team, the Navy tasks for 2012 are

1. Process and distribute N-18, N-19 and METOP-A GAC, and N-19 LAC (May and McKenzie)
2. Update data ingest to GDS 2.0 (May and McKenzie).
3. Implement calculation of analysis error estimates in FNMOC/NCODA global SST analysis (Cummings).
4. Evaluate impact of MISST data streams in NAVOCEANO assimilative ocean models on IOOS regional SST forecasts (Barron).
5. Disseminate NOAA and METOP AVHRR brightness temperatures from NOGAPS (Cummings).

WORK COMPLETED

1. Work is underway to process and distribute N-18, N-19 and METOP-A GAC, and N-19 LAC in GDS 2.0. The $25K for NAVOCEANO has been put on contract with QNA/John-Francois Cayula to work on tasks 1 and 2. Due to the late arrival of FY12 funding, additional work has begun on the NAVO MISST year-2 tasks of providing MetOp-B and SNPP VIIRS in GDS2.0 format.
2. Because NAVOCEANO operationally ingests some of the GHRSST data, this task has been completed with an update of the NAVO ingest of MSG SST GDS2.0 data from IFREMER OSI-SAF. So far this is the only GHRSST dataset available in GDS2.0 that we have interest in. As other GHRSST datasets of interest are updated to GDS 2.0 we will update our ingest.
3. This was in anticipation of a requirement from the L4 comparison group based on discussions at the Edinburg meeting. But Matt Martin has since stepped down and Alexey Kaplan has taken over as the lead of that group. Work on the L4 uncertainty estimates is on hold after the Tokyo meeting pending a new consensus for providing and intercomparison of L4 uncertainty estimates. See Dash et. al publication.
4. A report on the impact of assimilating polar orbiting versus geostationary infrared SST was provided at the Tokyo meeting with an IOOS-relevant focus on the gulf of Mexico. The details are included in the results section.

5. Atmospheric correction of the NAVO SSTs are on track for transisiton in FY13 and have relevance for the near real-time web-based L4-SQUAM (See Dash et al. publication)

RESULTS

Results of assimilating MISST data streams focused on a report to the Tokyo meeting comparing the impact of assimilating NOAA polar orbiting infrared AVHRR SST observations and/or GOES SST observations in data denial experiments. In a comparison with 364,266 independent in situ SST matchups from ship and drifter sources, the model forecasts assimilating GOES only showed the smallest nowcast bias (0.05°C), while the case assimilating AVHRR SST only showed the smallest 72-hour forecast bias (-0.20°C). RMS errors over the nowcast and 72-hour forecast windows were smallest when both GOES and AVHRR were used (0.83/0.95°C). The most significant finding was in the forecast bias and its seasonal trend. A seasonal breakdown of the matchups by local time of day provides additional insight into the forecast cold bias. Winter 2010-2011 and summer 2011 errors are largest in magnitude during midday to late afternoon. Bias is coolest in late afternoon, suggesting an underestimation of diurnal warming. In addition, biases are near zero in winter but 0.2-0.8°C cool in summer. A possible source of these discrepancies is a low bias in the incoming solar radiation. A 6-hour update cycle or FGAT approach using GOES observations might reduce analysis errors but would be unable to address the forecast bias; 3DVAR assimilation addresses errors in the initial state. A 4DVAR approach that jointly mitigates errors in the initial state and boundary conditions holds more promise in these cases. Alternatively, other methods have been developed to calibrate or adjust surface forcing according to satellite measurements of the terms in the bulk heat flux formulation. Work at NRL is progressing along these avenues in addition to continuing work on incorporating the GHRSST data streams into the Navy ocean forecast systems. These findings led to a new start proposal and will be transitioned into improved assimiative forecast adjustments.

Inclusion of atmospheric corrections via physical SST retrieval resulted in an 86% improvement in accuracy of NAVO SST retrievals relative to drifting buoy network. Reported in 6.4 program reviews.

IMPACT/APPLICATIONS

Provision of the NAVOCEANO-processed SST retrievals in the GDS 2.0 format will encourage broader adoption of the common standard, reducing the cost associated with maintaining different formats and simplificing the inclusion of other data streams into Navy systems.

The perfomance evaluations in the Gulf of Mexico have highlighted the forcast sensitivity to heat flux biases and led to new ways to evaluate and interpret forecast skill and uncertainty. It has also led to proposed 6.2 research into new methods to combine satellite observations with 4DVAR assimilation systems to reduce forecast bias.

The atmospheric corrections via physical SST retrievals will provide more accurate SST retrievals for calculations of sensible heat flux between the atmosphere and ocean. This in turn will provide more accurate hindcast and forecast smodel results, particularly when coupled with 4DVAR to extend the hindcast corrections into the forecast period.

TRANSITIONS

Use and provision of GDS 2.0 data has transitioned into operations at NAVOCEANO and FNMOC to be used daily (tasks 1 and 2). The additional capabilities are in the process of transitioning to these operational centers, to be used in daily assimilative analyses and forecasts.

RELATED PROJECTS

6.4 SPAWAR Interface analysis from satellite – ocean. Supports development and transition to Navy operations at NAVOCEANO and FNMOC of capabilities using satellite observations to estimate SST radiances, bulk SST, and heat fluxes across the air-sea interface. MISST for IOOS adds an IOOS emphasis for evaluation of these capabilities.

6.4 SPAWAR Space METOC – SST. Extended efforts to incorporate a constellation of geostationary SST estimates into global and regional assimoilative models with emphaiss on the resolving diurnal warming and its impact on upper ocean acoustics and heat content. Also accelerated efforts to minimise sensor bias between ploar orbiting microwave and infrared sensors, an error source that can alias sampling differences into spurious periodic temperature variations and negative impacts on subsurface forecast skill. These are to be transitioned to NAVOCEANO and FNMOC. MISST for IOOS adds an IOOS emphasis for evaluation of these capabilities.

PUBLICATIONS

1. Martin, M., P. Dash, A. Ignatov, V. Banzon, H. Beggs, B. Brasnett, J.F. Cayula, J. Cummings, C. Donlon, C. Gentemann, R. Grumbine, S. Ishizaki, E. Maturi, R.W. Reynolds, J. Roberts-Jones, 2012: Group for High Resolution SST (GHRSST) Analysis Fields Inter-Comparisons. Part 1: A GHRSST Multi-Product Ensemble (GMPE). *Deep-Sea Res. II*, **77-80**, 21-30. [published]
2. Dash, P., A. Ignatov, M. Martin, C. Donlon, B. Brasnett, R.W. Reynolds, V. Banzon, H. Beggs, J.F. Cayula, Y. Chao, R. Grumbine, E. Maturi, A. Harris, J. Mittaz, J. Sapper, T.M. Chin, J.Vazquez-Cuervo, E.M. Armstrong, C. Gentemann, J. Cummings, J.F. Piolle´, E. Autret, J. Roberts-Jones, S. Ishizaki, J.L. Høyer, and D. Poulter, 2012: Group for High Resolution SST (GHRSST) Analysis Fields Inter-Comparisons. Part 2: Near real time web-based Level 4 SST Quality Monitor (L4-SQUAM). *Deep-Sea Res. II*, **77-80**, 31-43. [published]
3. Barron, C.N., P.L. Spence, and J.M. Dastugue, submitted: Evaluation of assimilative SST forecasts in the Okinawa Trough and Gulf of Mexico. Proceedings, GHRSST XIII, 4-8 June 2012, Tokyo, Japan. [in press]